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ABSTRACT

To determine which types and qualities of science teaching strategies stimulate students to become involved in learning, middle and high school students (N=147) were observed for time-on-task (time actively spent by the student in learning) and off-task during periods while being taught by five student teachers. The "Teaching Strategies Observation Differential" (TSOD), rating teacher style on a scale from 0-10 (extremes defined as expository/direct and inductive/indirect), was used to measure verbal and non-verbal classroom activities. The quality of implementing strategies (lecture, direction, questioning, demonstration, investigation, response, or teacher guidance) identified by the TSOD was measured by an instrument developed for this study (included in an appendix). In addition, the "Test of Logical Thinking" (TOLT) was administered to determine possible relationships between developmental level and time-on-task. Results indicated that not only the type of teaching strategy, but also the quality of implementing that strategy have an influence on student time-on-task, suggesting that teacher education programs emphasize both a repertoire of strategies and the quality of implementing each type. Results also indicated that there was a relationship between formal reasoning ability and time-on-task, suggesting that teacher education programs also emphasize cognitive development theory and applications of this theory to instruction to facilitate learning. (Author/JN)

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A STUDY OF THE RELATIONSHIP AMONG TYPE AND QUALITY OF IMPLEMENTATION OF SCIENCE TEACHING STRATEGY, STUDENT FORMAL REASONING ABILITY, AND STUDENT ENGAGEMENT

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A STUDY OF THE RELATIONSHIPS AMONG TYPE AND QUALITY OF IMPLEMENTATION OF SCIENCE TEACHING STRATEGY, STUDENT FORMAL REASONING ABILITY, AND STUDENT ENGAGEMENT

Introduction

Effective teaching is an instructional factor which enhances student learning. Since the goal of education is to foster student learning, and the goal of teacher training programs is to promote teaching skills which help students learn, it is important to determine which types and qualities of science teaching strategies stimulate the students to get involved in the task of learning.

On-task time as defined by Carroll (1963) is that period of time actively spent by the student in learning. Student time-on-task has recently been a focus of classroom research, and has been found to be strongly associated with student achievement (Rosenshine, 1977: Hecht, 1978: Tobin & Capie, 1981). In addition, Fisher, Filby, Marliave, Cahen, Dishaw, Moore, and Berliner (1978) found that teaching processes had a direct influence on student academic learning time, which in turn affected student achievement.

Student characteristics also have an effect on the student's time-on-task (Carroll, 1963). Anderson (1975) and Good and Beckermen (1978) indicate that student cognitive entry behavior measured by the scores on the prior unit achievement test affects the amount of time that a student spends on-task. Tobin (1980) also states that a student's formal reasoning ability has an effect on student engagement. He suggests this variable should be considered when teaching strategies are planned or when classroom research is conducted. After a review of the research literature related to the student achievement-instructional time relationship, Lomax and Cooley (1979) suggested that future

research into instructional time should pay attention to the variable of student ability. They proposed the question of whether or not a high ability student spends as much engaged time in a specific content area as a low ability student for similar achievement gains to result in that content area. One purpose of this study is to determine whether or not there is a difference in engaged time for students of differing formal reasoning ability.

Anderson and Scott (1978) showed that on-task behavior of students tended to be related to classroom teaching strategy. The identification of effective teaching strategies is not an easy task. Earlier studies of the effects of teaching methods on student learning have examined the students and their behavior during instruction. At the same time, the focus of studies has moved from teacher characteristics to teacher behavior (Fisher et. al, 1978; Butts, 1981). Thus the ability of teachers to use strategies that increase student engagement remains a critical factor, and the teacher's task is to employ strategies that engage the students in learning tasks.

In addition to the type of teaching strategy, the quality of implementation of the strategy has an effect on student engagement. Studies reviewed by Rosenshine and Furst (1978) and by Dunkin and Biddle (1974) discussed differences in teaching methods. While those studies compared two methods of teaching to find out which was better, measurement of the quality of teaching within a specific strategy is rarely mentioned. Two teachers may both use lecture in their classes, but one may involve students in learning more than the others. Examination of the type of teaching strategy and its effort on student engagement is thus insufficient to fully account for differences in student performance without considering the quality of implementation of the teaching strategy. In this study, the relationship between the quality and

type of teaching strategy and student engagement is examined.

Rationale

The teacher has the responsiblity for establishing an effective classroom environment, and is a primary factor influencing student engagement. Classroom observations of the teacher's teaching techniques have been employed to find out what types of student engagement is related to what a teacher has or has not done (Hess, Takanishi-Knowles, & Thomson, 1973). Various teaching methods have been tested to examine which methods are more effective in improving student learning outcomes. In a research study investigating direct teaching behavior, Flanders (1965) used interaction analysis to measure student achievement and attitude. The results showed that both student attitude and achievement scores were superior for classrooms in which the teacher was more indirect. LaShire and Westmeyer (1967) found that students in indirect classes had higher achievement scores than students in direct classes. Also, the indirect classes showed higher scores in attitudes toward the teacher and toward school work. Wolfson (1973) also found that high school chemistry and junior high school general science students taught by teachers with higher indirect/direct ratios learned and retained more information than did students of teachers with lower indirect/direct ratios. Shymansky and Matthew's (1974) experimental study revealed a significant difference in student investigation skills in favor of the indirect pattern of teaching. Dillashaw and Yeany (1981) and Yeany (1977) argued that significant differences in science achievement and attitude generally favor indirect teaching strategies. Teaching strategies are also related to student academic engagement, and engagement in school activities in a prerequisite to learning and academic achievement (Hess et. al, 1973).

Taking another point of view, Bloom (1976) hypothesized that student entry characteristics influence learning even more than variations in teaching. Evertson and Anderson (1978) found that achievement of high aptitude students was not influenced as much by teacher behavior as was that of low aptitude students. They emphasized that high aptitude students did well regardless of the teacher behaviors. Also, Tobin and Capie (1980) noted that students with high formal reasoning ability formulated appropriate responses and spent more time in decisions, while students with low levels of formal reasoning ability had difficulty responding, and had a greater incidence of off-task behavior.

In addition to teaching strategies and student formal reasoning ability, the quality of implementation of those strategies should be considered. Even within a single type of teaching strategy, the quality of implementation varies and may make a difference.

Purpose

The purposes of this study were to examine how the type and quality of implementation of science teaching strategy and student formal reasoning ability are associated with student engagement. These purposes are summarized in the following research questions.

1. Is there a relationship between type of science teaching strategy and student engagement?

2. Is there a relationship between quality of implmentation of a science teaching strategy and student engagement?

3a. Is there a relationship between student engagement and student formal reasoning ability?

b. Do students with high levels of formal reasoning ability spend more time academically engaged than students with low levels of formal reasoning ability?

4. Is there any difference in student engagement within each type and its quality of implementation of science teaching strategy?

Method

Subjects

One hundred forty seven students in fourteen classes in middle and high schools in Georgia were observed for on-task or off-task behavior during periods while being taught by five student teachers. At the same time, each student teacher's teaching strategy was recorded. Even though five teachers were involved in this study it is not the teacher that was the focus but rather their teaching behaviors. Therefore a single teacher could provide many types of teaching strategies to analyze. A total of 39 observation sessions (ten for three teachers, four and five for another two teachers) were made during fall quarter, 1981.

Instrument Description

The Teaching Strategies Observation Differential (TSOD) (Anderson, Struthers, and James, 1974) was used to identify teaching strategy. This instrument provides a measure of teaching strategy in both verbal and nonverbal classroom activites. The TSOD was selected because of its ability to generate a score on a direct-indirect teaching strategy continuum. This instrument rates teacher style on a scale from 0-10 with extremes defined as expository/direct (i.e. lecture) and inductive/indirect teaching (i.e. student activated investigation). The TSOD defines the levels of teaching strategy as follows:

I. Noneducational Activties
   - 0_1 Noneducational activities beyond the teacher's control
   - 0_2 Teacher-controllable noneducational activities

II. Direct Verbal
   1. Facts (lecture)
   2. Direction or opinion
   3. Limiting questions

III. Direct Nonverbal
   4. Demonstration
   5. Student exercises ("cookbook")

IV. Indirect Verbal
   6. Teacher questions
   7. Teacher response
   8. Teacher guidance

V. Indirect Nonverbal
   9. Teacher-planned open-ended investigations
   10. Student-planned investigations

The quality of implementation of each teaching strategy (lecture, direction, questioning, demonstration, investigation, response, or teacher guidance) identified by the TSOD was measured using the Teaching Strategy Quality Scale (TSQS) which was developed by the present investigators. A rating score (on a 1-5 scale) represents the presence of the five criteria which define quality for each teaching strategy. High quality is indicated by a greater number of criteria being met (see Figure I).

The Test of Logical Thinking (TOLT) (Tobin & Capie, 1980) was used to measure the formal reasoning ability of the students. This instrument consists of ten items that measure formal reasoning on five dimensions: proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, correlational reasoning. TOLT has a high internal consistency coefficient ($\alpha = .85$). Scores of 0-1 on TOLT indicate a concrete operational level of development. Scores 2-3 indicate a transitional stage of development and score 4 or higher represents formal operational levels of development. TOLT was administered to students shortly after the last observations were made.

Procedures

Ten students seated in various locations in the classroom were randomly selected for each observation. The same students were observed throughout the investigation. In some periods the student to be observed was absent; a new student was randomly selected for observation, Instead of 140 student (10 students from each 14 classes), the total number of students was 147. Each student was observed for five seconds in every minute during the class period (50-55 minutes), and his/her behavior was coded into one of the following four categories (Anderson, 1976):

a. paying attention--listening, looking at teacher or at book.
b. working on the task--taking notes, solving problems, or reading.
c. working with the others on the task--talking to the teacher or peers, or asking questions.
d. engaging in behavior that is not involved in the learning task.

A student who was engaged in category a, b, or c behaviors received a score of 1. A student who was engaged in category d behavior received a score of 0.

Thirty-nine 50-55 minute observation sessions took place across all classrooms. Observation started at the beginning of the period. In the first ten seconds the rater observed the teacher and recorded the appropriated TSOD category. During successive five second intervals, the rater observed each student in the student sample in order, and recorded the on-task behavior. Thus, each student was observed every 60 seconds during the observation time. The predominant behavior was coded if more than on type of teacher or student behavior was observed during the interval. Quality of each teaching strategy was assessed with the TSQS after a teaching strategy was terminated and a new one exhibited.

Although fourteen classes were involved in this study, the units of analysis were the 39 occasions of observation (50-55 minute periods) and the 1994 observation intervals (1 minute), not the teacher or classes. For each class, ten students were randomly selected and their on-task and off-task behaviors observed, so the total 390 occasional observations were recorded for all students. Because of school activities (e.g. assembly, sports, clubs, picture taking), the full 50 or 55 minutes of some periods were not observed. However, 1994 intervals (i.e. 1994 minutes) were spent observing teaching strategies and student time-on-task.

Data Analysis and Findings

A null hypothesis was tested in relation to each of the research question stated earlier. As indicated, the units of analysis were the occasions and intervals of observation. In interval observation analysis the variables of type and quality of implementation of sciences teaching strategy and student engagement were considered. In occasional observation analysis, the student formal reasoning ability variable was added.

Hypothesis I

There is no relationship between the type of science teaching strategy and student engagement.

The mean, standared deviation, minimum, and maximum scores of teaching strategy are given in Table I. For the 390 occasional observation, it was found that the maximum, minimum, and mean scores of teaching strategy were 4.9,1, and 2.95 respectively. The teaching strategy scores indicated that the teachers' style fell toward the expository/direct end of the continuum.

For the 1994 interval observations, it was found that scores on the direct-indirect teaching strategy continuum ranged from 0 to 7. It means that TSOD #0_1 and 0_2 to # 7 were employed and TSOD #8 (teacher guidance), TSOD #9 (teacher-planned open-ended investigations), and TSOD #10 (student-planned investigations) were not implemented by teachers in this study.

This hypothesis was rejected at the .0001 level of confidence when interval observation was a unit of analysis as indicated in Table II. But when occasional observation was a unit of analysis, this hypothesis could be rejected at the .005 level of confidence.

Hypothesis II

There is no relationship between the quality of implementation of a science teaching strategy and student engagement.

From Table I for 390 occasional observations, it was found that the maximum, minimum, and mean scores of quality of implementation were 4.9, 2.6, and 3.85 respectively. These scores indicated that overall quality of implementation by teachers was good.

For 1994 interval observations, the maximum score 5 of quality of implemenatation indicated that all quality criteria for that particular teaching strategy were employed. The minimum score 0 means that noneducational activities were being implemented because there were no quality criteria for TSOD #0_1 and 0_2.

This hypothesis was rejected at the .0001 level of confidence when interval or occasional observations were the units of analysis, as shown in Table II.

Hypothesis III a.

There is no relationship between student engagement and student formal reasoning ability.

The mean, standard deviation, minimun, and maximum scores of student formal reasoning ability are given in Table I. For 390 occasional observation, the TOLT indicated that this study included students who possessed levels of cognitive development ranging from 0 (concrete) to 10 (formal). This hypothesis was rejected at the .0005 level of confidence, as indicated in Table II.

The results from hypothesis I, II, and III a only indicated whether there was a relationship between (1) type of science teaching strategy, (2) quality of implementation of a science teaching strategy, and (3) student formal reasoning ability and student engagement. Only simple correlation was utilized. It was important to find out whether more than one independent variable (teaching strategy, quality of teaching, and student formal reasoning ability) would better predict student engagement. Multiple correlation was used to find the best predictors of student engagement among those independent variables. The results are shown in Table III, IV, V, and VI.

If the interval observation is used as the unit of analysis without consideration of student formal reasoning ability, the results from Table III and IV indicate that the type and quality of implementation of teaching strategy did significantly and positively predict student engagement. Analyzed individually, the type of teaching strategy predicted 12 percent of the variance in engagement, while the quality of implementation of teaching strategy predicted 73 percent of the variance in engagement. Together both factor models, the type and the quality of teaching strategy, predicted 74 percent of the variance in engagement.

If the occasional observation is used as the unit analysis with consideration of the variable of student formal reasoning ability, the results from Table V and VI also indicate that the type and quality of implementation of teaching strategy and student formal reasoning ability did significantly and positively predict student engagement. Analyzed individually, the type of teaching strategy predicted 2 percent of the variance in engagement, while student formal reasoning ability and the quality of implementation of teaching strategy predicted 3 and 16 percent of the variance in engagement, respectively. Overall, the three factor models including the type and quality of implementation of teaching strategy and student formal reasoning ability, predicted 18 percent of the variance in engagement.

Hypothesis III b.

Students with high levels of formal reasoning ability spend as much time academically engaged as students with low levels of formal reasoning ability.

Results from Table II indicated that there was a relationship between student formal reasoning ability and student engagement ($r = .18$, $p = .0005$). Table VII shows mean engagement score of students in each TOLT score test. Mean engagement score of concrete students ($n = 74$) was .76, of transitional students ($n = 29$) was .80, and of formal students ($n = 44$) was .81. From Table VIII general linear model analysis revealed that TOLT, when treated as a continuous variable, was a significant predictor of student engagement ($p=0.02$). When TOLT was used as a class variable (concrete level with TOLT scores 0 and 1, transitional level with TOLT scores 2 and 3, and formal level with TOLT score 4 to 10), it was found that TOLT was not a significant predictor of student engagement ($p = 0.08$).

Hypothesis IV

Within each type of science teaching strategy, there is no difference in student engagement by quality of implementation.

Mean engagement scores corresponding to the type and quality of implementation of science teaching strategy are shown in Table IX. Only TSOD #0_1 and 0_2 to #7 were observed from this study so each teaching strategy observed student mean engagement score increases as the criteria of the quality of its teaching strategy are added up. For instance, using TSOD #1 with only one criterion of its quality, student mean engagement score is .1, with two, three, four, and five criteria mean engagement scores are .42, .6436, .7802, and .8967 respectively.

Conclusions

Not only the type of teaching strategy, but also the quality of implementation of that strategy has an influence on student engagement. Classroom teachers should work for high quality. Bracht (1970) has indicated that no single instructional strategy is best for every student. Some students will achieve more with one strategy while other students will achieve more with another. Given the situation of a classroom of students with unique aptitudes, teachers might profitably give more attention to the quality of teaching. Any type of teaching strategy taught well can help a student become more involved in the learning situation.

In a teacher training program, student teachers are taught how to use the types of teaching strategies appropriate to the content, student knowledge, and classroom activities. In addition, quality of teaching must be emphasized and considered a major goal of the program. Each student teacher has his/her

own repertoire of teaching strategies. Attention to high quality in each type of teaching will make teaching more effective and stimulate student engagement. A teacher training program is insufficient if it emphasizes only the types of teaching strategies and ignores the quality of those strategies.

In addition, student formal reasoning ability should also be considered by teacher. Research reviewed by Sayre and Ball (1975) indicated that secondary science instruction should be structured around student cognitive development levels. Besides emphasizing both type and quality of implementation of teaching strategy, teacher training institutions should help student teachers understand cognitive development theory and apply that theory to their instruction to facilitate student learning. Further research should also be done to find out what kinds of instruction that facilitate and improve student formal reasoning ability.

TEACHING STRATEGIES QUALITY SCALE (TSQS)

The following instrument is based on the Teaching Strategies Observation Differential (TSOD). It is used to assess the quality of teaching. Each teaching strategy is assessed on the stated criteria. A rating score (on a 1-5 scale) represents the criteria which best define each teaching strategy.

Ratings

1. One of the criteria is evident.
2. Two of the criteria are evident.
3. Three of the criteria are evident.
4. Four of the criteria are evident.
5. Five of the criteria are evident.

LECTURE (1)*

1. The content and/or objectives are directly communicated to the students.
2. The content of the lecture is broken into distinctive parts, for example, precisely defining, exemplifying, and relating a basic concept.
3. The main ideas presented are accurate as well as appropriate to the background and abilities of the students.
4. Key points of a topic are emphasized by repetition, for example, writing them down or saying their importance.
5. A variety of approaches, such as, the blackboard, charts, graphs, etc., is included in the lecture.

DIRECTION (2)*

1. Directions are clear and/or appropriate to the task.
2. Directions are suitable to the abilities of the students
3. The reasons for the task or procedure are explained.
4. Directions are checked for misunderstanding.
5. Directions are given without an arbitary use of power.

QUESTIONS (3,6)*

1. Questions are phrased directly, simply, and clearly.
2. A mixture of easy and difficult question is asked
3. Questions are appropriate to the objectives.
4. Adequate wait-time is used after questioning and responding to that question.
5. Questions create a discussion atmosphere by stimulating students' sense of curiosity and inquiry.

DEMONSTRATION (4)*

1. The objectives to be achieved by the demonstration are clear both to the teacher and the students.
2. The materials and equipment used in the demonstration are carefully prepared and ready for use.
3. The key points of the content in the demonstration are stressed and emphasized clearly.
4. A variety of approaches, such as, the blackboard, charts, graphs, pictorial material, or a short motion picture is included in the demonstration.
5. The demonstration is tied into previous learning.

INVESTIGATION (5,9,10)*

1. The investigation illustrates the objectives of a particular topic.
2. The activities selected are relevant to the current topic being studied.
3. The investigation starts from a simple situation or a set of questions to more sophisticated analyses.
4. The investigation allows the students to examine and explore facets of the problem and use process skills in generating information and solving problems.
5. The investigation matches the background experiences and abilities of the students.

For the categories 9 and 10, criteria 1 and 2 are:

1. The investigation illustrates the general objectives concerning the topic being studied.
2. The activities selected are relevant to the topic being studied.

RESPONSE (7)*

1. Teacher response is clear and understood by the students.
2. Teacher response clarifies one student's answer or comment to another student.
3. Teacher response stimulates student critical thinking.
4. Teacher response provides feedback to student's questions or comment.
5. Teacher response is accepting or using student's answer and idea to continue class discussion.

TEACHER GUIDANCE (8)*

1. Teacher guidance is appropriate to the objectives.
2. Teacher guidance leads the students to see the relationships of their findings to the key concepts of each topic.
3. Teacher guidance stimulates the students to resolve the uncertainties from the experimental results.
4. Teacher guidance helps the students base their ideas and conclusions on previous experience and evidence.
5. Teacher guidance aids the students to develop their abilities in forming explanation and implication.

* The numbers in parentheses refer to the categories in the TSOD.

Figure 1. Teaching Strategies Quality Scale (TSQS)

Table I

Means, Standard Deviations, Minimum, and Maximum Scores of the Variables in Occasional and Interval Observations

Observation	Variable	N	Mean	Standard Deviation	Minimum	Miaximum
Occasional	TOLT	390	3.18	2.76	0	10.00
	Strategy	390	2.95	1.00	1	4.90
	Quality	390	3.85	0.54	2.6	4.90
Interval	Strategy	1994	2.94	2.05	0	7.00
	Engagement	1994	0.78	0.27	0	1.00
	Quality	1994	3.86	1.45	0	5.00

Table II

Correlation Matrix of Predictor and Criterion Variables Based on Occasional and Interval Observations

Observation	Variable	1	2	3	4
Occasional	1. TOLT	1.0000 (390) p=0.0	0.1214 (390) p=0.016	0.0731 (390) p=0.150	0.1753 (390) p=0.0005
	2. Strategy		1.0000 (390) p=0.0	0.2172 (390) p=0.0001	0.1422 (390) p=0.005
	3. Quality			1.0000 (390) p=0.0	0.3973 (390) p=0.0001
	4. Engagement				1.0000 (390) p=0.0
Interval	2. Strategy		1.000 (1994) p=0.0	0.3361 (1994) p=0.0001	0.3429 (1994) p=0.0001
	3. Quality			1.0000 (1994) p=0.0	0.8566 (1994) p=0.0001
	4. Engagement				1.0000 (1994) p=0.0

Table III

Regression Analysis for the Relationship between the Type and Quality of Implementation of Teaching Strategy and Student Engagement in Interval Observations

Source	df	SS	F	p	R^2
Model	2	107.03	2791.10	0.0001	0.74
Error	1991	38.18			
Total	1993	145.21			

Table IV

Results of Multiple Regression Analysis Showing the Single and Multiple Variable Models Which Predicted Engagement in Interval Observations

Number in Model	R^2	Variables in Model
1	0.1175	Strategy
1	0.7337	Quality
2	0.7371	Strategy Quality

Table V

Regression Analysis for the Relationship among the Type and Quality of Implementation of Teaching Strategy and Student Formal Reasoning Ability and Student Engagement in Occasional Observations

Source	df	SS	F	p	R^2
Model	6	2.03	14.33	0.0001	0.18
Error	383	9.04			
Total	389	11.07			

Table VI

Results of Multiple Regression Analysis Showing the Single and Multiple Variable Models Which Predicted Engagement in Occasional Observations

Number in Model	R^2	Variables in Model
1	0.0202	Strategy
1	0.0307	TOLT
1	0.1579	Quality
2	0.0456	TOLT Strategy
2	0.1611	Strategy Quality
2	0.1794	TOLT Quality
3	0.1811	TOLT Strategy Quality

Table VII

Mean Engagement Scores of Students with Various Levels of Cognitive Development

TOLT Score	N	Mean Engagement Score	Standard Error of Mean	Level of Cognitive Development	N	Mean Engagement Score
0	42	0.75	0.17			
1	32	0.79	0.15	Concrete	74	0.76
2	15	0.80	0.08			
3	14	0.81	0.15	Transitional	29	0.80
4	11	0.79	0.14			
5	9	0.76	0.18			
6	6	0.82	0.10			
7	6	0.80	0.07	Formal	44	0.81
8	6	0.87	0.06			
9	4	0.93	0.05			
10	2	0.77	0.10			

Table VIII

General Linear Model Analysis for the Relationship between TOLT Scores and Student Engagement in Occasional Observations

	Source	df	SS	F	P	R^2
Continuous Variables	TOLT	1	0.11	5.36	0.02	0.04
	Error	145	2.95			
	Total	146	3.96			
Class Variables	TOLT	1	0.07	3.19	0.08	0.02
	Error	145	2.99			
	Total	146	3.06			

Table IX

Mean Engagement Scores Corresponding to the Type and Quality of Implementation of Science Teaching STrategy in Interval Observations*

Strategy / Quality	0 Noneducational Activities	1 Facts (lecture)	2 Direction or Opinion	3 Limiting Questions	4 Demonstration	5 Student Exercises	6 Teacher Questions	7 Teacher Response
0	0.1061	-	-	-	-	-	-	-
1	-	0.1000	-	0.3538	-	-	-	0.3000
2	-	0.4200	0.4857	0.4000	0.5222	-	-	0.4692
3	-	0.6436	0.6263	0.6852	0.6400	0.6667	0.6000	0.6873
4	-	0.7802	0.9050	0.9010	0.8336	-	0.8000	0.8257
5	-	0.8967	0.9162	-	0.9555	0.9139	0.8886	-

* - Empty cells indicate no observations of that strategy at that level of quality

Bibiliography

Anderson, L.W. Student involvement in learning and school achievement. California Journal of Educational Research, 1975, 2, 53-62.

Anderson, L.W. An empirical investigation of individual differences in time to learn. Journal of Educational Psychology, 1976, 68, 226-233.

Anderson L.W., & Scott, C.C. The relationship among teaching methods, student characterisitcs and student involvement in learning. Journal of Teacher Education, 1978, 29, 52-57

Anderson, R., James, H., & Struthers, J. The teaching strategies observation differential. In G. Stanford and A.E. Roark (Eds), Human interaction in education, Boston: Allyn and Bacon, 1974

Bloom, B.S. Human characterisitcs and school learning. New York: McGraw-Hill Book Company, 1976.

Bracht, G.H. Experimental factors related to aptitude treatment interactions; Reviews of Educational Research, 1970, 40, 627-645

Butts, D.P. A summery of research in science education--1979. Science Education, 1981, 65, 335-435.

Carroll, J.B. A model of school learning. Teacher College Record, 963, 64, 723-733

Dillashaw, F.G., & Yeany, R.H. The use of strategy analysis to train teachers in the application of selected teaching strategies. Unpublished manuscript, 1981.

Dunkin, M., & Biddle, B. The Study of Teaching. New York; Holt, Rinehart and Winston, 1974.

Evertson, C., & Anderson, L. Interim progress report: The classroom organization study. Austin, Texas: Research and Development Center for Teacher Education, University of Texas at Austin, Report NO. 6002, 1978.

Fisher, C.W., Filby, N.N., Marliave, R., Cahen, L.S., Dishas, M.M., Moore, J.E., & Berliner, D.C. Teaching behaviors, academic learning time and student achievement: An overview of phase III-B of the beginning teacher Evaluation Study. Paper presented at the annual meeting of the American Educational Research Association, Toronto, Canada, March 1978, (ERIC Document Reproduction Service No. ED. 183 525).

Flanders, N.A. Teacher influences, pupil attitudes, and achievement. U.S. Department of Health, Education, and Welfare, Office of Education, Cooperative Research Monograph No. 12, Washington, D.C.: Government Printing Office, 1965.

Good, T.L. & Beckermen, T.M. Time-on-task: A naturalistic study in sixth-grade classrooms. Elementary School Journal, 1978, 78 193-201.

Hecht, L.W. Measuring student behavior during group instruction. Journal of Educational Research, 1978, 81, 283-290

Hess, R.D., Takanishi-Knowles, R., & Thomson, M.L. Teacher strategies and student engagement in low-income schools. Research and Development Memorandum No. 105. Stanford Center for Research and Development in Teaching, Stanford University, California, February 1973, (ERIC Document Reproduction Service No. ED 087 768)

LaShire, W.S., Jr., & Westmeyer, P. The use of interactional analysis in BSCS laboratory block Classrooms. The Journal of Teacher Education, 1967, 18, 439-446

Lomax, R.G., & Cooley, W.W. The student achievement-instructional time relationship. A paper presented at the annual meetings of the American Educational Research Assocaition, San Franciso, April 1979. (ERIC Document Reproduction Service No. ED 179 598)

Rosenshine, B.V. Primary grades instruction and student achievement gain. A paper presented at the American Educational Research Association annual meeting, New York, 1977.

Rosenshine, B., & Furst, N. The use of direct observation to study teaching. In R. Travers (Ed.), Second Handbook of Research on Teaching. Chicago: Rand McNally, 1973.

Sayre, S., & Ball, D.W. Piagetian cognitive development and achievement in science, Journal of Research in Science Teaching, 1975, 12, 165-174.

Symansky, J.A., & Matthews, C.C. A comparative laboratory study of the effects of two teaching patterns on certain aspects of the behaviors of students in fifth grade science. Journal of Research in Science Teaching, 1974, 11, 157-168.

Tobin, K.G., & Capie, W. The development and validation of a group test of logical thinking. A paper presented at the annual meeting of the American Educational Research Association, Boston, Massachusetts, April 1980.

Tobin, K.G. The effects of variations in teacher wait-time and questioning quality on integrated science process achievement for middle school students of differing formal reasoning ability and locus of control. Unpublished Dissertation, University of Georgia, 1980.

Tobin, K.G., & Capie, W. Pupil engagement in learning tasks: A fertile area for research in science teaching, Journal of Research in Science Teaching, 1981, 18, 409-417

Wolfson, M.L. A consideration of direct and indirect teaching styles with respect to achievement and retention of learning in science classes. Journal of Research in Science Teaching, 1973, 10, 285-290.

Yeany, R. The effects of model viewing with systematic strategy analysis on the science teaching styles of preservice teachers. Journal of Research in Science Teaching, 1977, 14, 209-222.